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Journal of Geological Education

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FOREIGN LANGUAGES FOR GEOLOGISTS*

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ABSTRACT. An attempt is made to convince the reader that, given a geological background and a desire to learn, a knowledge of any foreign language, adequate for reading geological papers, is much more easily achieved than generally suppposed. With sufficient grounding in three languages (French, German, and Russian) the door is opened to nearly all the world's geological literature.

The neglect of the foreign literature by English-speaking scientists has been deplored in print often enough. If the number of uncut pages in foreign periodicals in our geology libraries compared with those in other sciences is any criterion, geologists and geophysicists are among the worst offenders, but the problem is by no means limited to the earth scientists. Not long ago almost half of an entire issue of the "Journal of Chemical Education" (see References Cited) was devoted to papers exhorting chemists to learn foreign languages, and offering suggestions and aids to that end. For earth scientists the need is still more acute, as we lack the degree of coverage offered by "Chemical Abstracts"; but even if we enjoyed an equal advantage in this respect, an abstract at best is not a substitute for, but only a guide to the content of, the original paper.

The opinions that follow regarding the so-called language barrier have been formed during the course of several years' work abstracting and translating foreign papers in geology and geophysics. Because these opinions are based on the experience of a geologist who started with little more language background than the average Ph.D. candidate, they may possibly be of more practical interest to earth scientists than more learned discussions by language experts.

1. *The language barrier has assumed unnecessarily formidable proportions largely because of a popular misconception.* This misconception, implicit in the often-heard statement that the only time to learn a language is in childhood (Campbell, 1957, p. 26), is rooted in the confusion between learning to *speak* a language and learning to *read* it. In point of fact, the two are entirely distinct disciplines. When it comes to speaking with correct accent, it is perfectly true that childhood is the best time to learn. No matter how fluent or grammatically correct he may be, only the rare individual can pronounce like a native a language he has learned after his formative years. Learning to speak one's native language thus in a sense makes it harder to learn to speak other languages. When it comes to reading, however, the reverse is true. We do not learn to read English as we

* Publication authorized by the Director, U. S. Geological Survey.

learn to talk; talking comes naturally, by imitation, but reading must be taught at a later date. Once we have learned to read any one (phonetic) language, that discipline is applicable to any other. In other words, learning to read one's native language makes it easier to learn to read others. Just as it is possible for a person to speak one or more languages and yet be completely illiterate, so is it possible to be able to read one or more foreign languages and yet not understand any of them by ear. For example, how many of us can read French tolerably well, yet find that the dialog in a French film races by, incomprehensible except for a word here and there?

2. *An adequate background for scientific reading in any language can be acquired in a first-year college course or the equivalent.* Of course this is a minimum; any further study is all to the good. The bare essentials for a reading knowledge are (a) the fundamentals of grammar; (b) some knowledge of pronunciation; (c) a bilingual dictionary; and (d) PRACTICE. Let us consider these points separately.

(a) Compared to "literary" writing, scientific writing on the whole is more simple and straightforward, and is relatively devoid of complicated figures of speech, flourishes of style, and colloquialisms. By the end of any good first-year course the student should have learned enough of the grammer and common idioms to read simple prose with the aid of a dictionary.

(b) In reading, one mentally pronounces the words (Dostert, 1955, p. 130). Although it is possible to read without having the slightest idea of the true pronunciation, it definitely aids the recognition of words to use at least a reasonable approximation of their correct sounds. To take a very simple example, if one knows that the German word "Haus" is pronounced like "house", it may not be necessary to look it up at all to find it means exactly that. The very first lesson of any language course usually gives the basic rules of pronunciation.

(c) For English-speaking earth scientists, no complete bilingual or polyglot technical dictionary is yet available in any language, but that is a disadvantage chiefly to translators who lack geological background. A high proportion of technical terms are more or less similar in all languages and can be recognized without recourse to dictionaries. (Who could fail to recognize "feldspath" and "Feldspat", in French and German respectively, as "feldspar"? Even "polevoĭ shpat" in Russian, literally translated to "field spar", isn't too hard to figure out, especially if one already knows that "field" is "Feld" in German.) This makes scientific reading much easier than non-technical, for the scientist. In fact, the writer is convinced that *comprehension of a foreign paper depends much more on knowledge of the subject than on knowledge of the language.* As one's reading naturally tends to be concentrated in one's own specialty, over half the battle is won before the start!

The words most likely to be looked up are the "everyday" words, for which any good bilingual dictionary will suffice. These gradually become part of the working vocabulary. Sometimes a common word is used in a special sense, as

we use "bed" in a geological sense in English; "couche" is used similarly in French. Sometimes, as in English, a word has a number of possible meanings: the German word "Fläche" for instance, may mean "surface, face, flatness, plain, expanse, level, sheet, area, plane, facet".[1] In such cases, who can decide better than the expert which word best fits the context?

(d) Practice — there's the rub! If the reading knowledge, once acquired, is not used, it deteriorates rapidly. It must be kept fresh by frequent mild exercise, such as by reading titles and abstracts in foreign periodicals as they are received. Then it is ready for use when a paper deserving more thorough treatment comes along. Sooner or later there comes the rewarding day when the reader finds himself comprehending without mentally translating each word or phrase into English — and that day comes sooner than he thinks.

3. *A knowledge of three foreign languages will put most of the world's geological literature at one's command.* The three are French, German, and Russian. A high proportion of papers of more than purely local interest are published in one of these or English, or carry summaries (for what they are worth) in one of the "big four". But there is a lot more to it than that. Once one has learned any one of the Romance languages (French is recommended as the first because the others seem to be a little easier after it than vice versa), the fundamentals of the others can be gleaned without formal study from a grammar book or manual, or even by trial and error with a dictionary. French thus opens the door to Italian, Spanish, and Portuguese. High-school Latin is helpful here, by the way, but not essential. Similarly, a knowledge of German paves the way for Dutch and the Scandinavian languages, and the Russian for the other Slavic languages (including Polish, Czech, and Serbo-Croatian, which use our Latin alphabet). Every new language not only makes the next one easier, but also helps with languages already known.

The best time to take French probably is in high school and/or freshman year in college, German later in college, and Russian early in graduate work.

Several variables affect the ease with which a particular paper may be read. First is the nature of the language itself. After one year each of French, German, and Russian, the average English-speaking scientist probably will find that in French the only serious hindrance is his still-limited vocabulary, a hindrance which diminishes with practice. In German, the unfamiliar word-order, the use of compound words, the declension of nouns, and other grammatical complexities may still be confusing, although many words are similar to English ones. After a year of Russian, however, the dictionary and grammar book probably will be consulted much more frequently than in the other two languages. Not only is the grammar quite complicated, but the Slavic roots are so different that it requires more effort to remember words, because there is less in one's experience with which to associate them.

The next variable is the nature of the subject. In any language, a discussion of the philosophical aspects of some fundamental theory is far heavier going than

[1] De Vries' German-English Science Dictionary, second edition.

a paper presenting the neatly tabulated results of a series of measurements. In the latter case the main facts can be grasped even by someone with no training in the language, if he can use a dictionary to look up the headings of the tables.

Finally, there is the clarity of writing. Foreign authors are no different from our own in that some write lucidly, some passably, and some downright obscurely.

4. *The habit of using foreign literature must be instilled early or it doesn't "take".* These days, all geology majors in recognized institutions have been exposed to at least one foreign language by the time they reach junior or senior year. Why not encourage use of that knowledge while it is fresh, you teachers who consider it worthwhile? If not all students are qualified or interested, could not some incentive, such as extra credit, be furnished for those who are? At the graduate level, occasional assignments in foreign journals could be routine. In some colleges special work leading to a degree with honors in the major subject is optional after the sophomore year. One of the requirements when the writer followed such a program some years ago was a reading knowledge of French and German, with exams at the end of senior year fully comparable to those demanded of Ph.D. candidates. The knowledge thus acquired (based on high-school and college French, and a year and a half of college German) was used intermittently during graduate study, survived a ten-year interruption, and later, with the addition of a year of Russian and steady part-time use, has been parlayed into an admittedly sketchy but entirely workable reading knowledge of ten or twelve other languages.

5. *The mistaken belief that a special "gift of tongues" is required deters many from attempting to surmount the language barrier.* The writer was only a fair to mediocre language student in college and cannot even boast of a good memory for vocabulary. A good memory is undoubtedly a time saver, but other assets are more valuable. First and foremost, there is the desire to learn. The student who regards a new language as a challenge will do much better than one who finds it a chore. Also very important is the ability to make "educated guesses." As an educated guess is merely a logical deduction based on past experience, the broader one's background in the subject and in languages (including English) the more successful it will be. Many words never before encountered can be figured out by analysis of their parts, aided by the context. Consider the Spanish word "altiplano": with no language but English, one might reason that "alti" (as in altitude) probably means high, and "plano" (suggesting "plane") a flat surface, and therefore the whole ought to mean "plateau" — which it does. (The person to whom "high plane" suggests an airplane probably will have trouble, not only in languages but in other fields of learning too!) Thus learned, "altiplano" is not easily forgotten, and furthermore it is then only a short step to the Italian "altipiano". Now words like "altiplano" can be found in many dictionaries, but there are some technical terms that are neither easily recognized nor given in commonly available dictionaries. In such cases the only way to find the meaning is by deduction. A rather esoteric example is the Russian word "mindalekamennyĭ", used in a petrographic description of a spilite. The second part of the word, "kammennyĭ", means "stone" (used as an adjective), and therefore finds its way

into a geologist's Russian vocabulary quite early; but the only word in the dictionary resembling the first part is "mindalina", meaning almond. "Almond-stone spilite" doesn't make any sense unless the reader knows some petrology, and thus knows (or should know!) the derivation of the term "amygdaloidal"—and this brings us right back to the argument that knowledge of the subject is more important than knowledge of the language.

These remarks have been offered in the hope that they may help make the language barrier less terrifying for at least a few. One parting thought: the first paper in any language is the hardest; once started, the way is all downhill and the acceleration terrific.

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PREPARATION OF MANUSCRIPTS

It will be most appreciated if authors of papers to be submitted to the *Journal of Geological Education* will follow these simple recommendations.

(1) Make your paper as concise as possible. As the *Journal* appears only twice a year, space is at a premium.

(2) Double-space *everything*—abstract, text, quotations, lists of references.

(3) Follow the format of papers published in recent issues of the *Journal*.

(4) Simple tables, such as lists, should be typed, so that they can be set in print. Complicated tables, involving many ruled spaces, special symbols, etc., should be drafted, with the lettering done with a guide or a new black typewriter ribbon, so that they can be reproduced photographically.

(5) Do not include line drawings unless absolutely necessary.

(6) Because of expense of reproduction, and the necessity of using coated paper, photographs are acceptable only under the most exceptional circumstances.

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ISOGYROMETER: A DEVICE FOR ILLUSTRATING ISOGYRE THEORY

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ABSTRACT. By means of a relatively simple mechanical device, called an isogyrometer, it is possible to show students of optical mineralogy why isogyres exist, why they behave as they do, and how the positions of the optic elements can be determined from interference figures. The isogyrometer consists of a box-frame supporting a rotatable sphere that can be viewed through a circular window representing the microscope field. Lines of equal velocity (isotaques) are drawn on the sphere, and lines representing the vibration directions of the crossed polarizers in a microscope are drawn on the window. Where the isotaques and the lines on the window are parallel, light would be extinguished under the microscope, producing isogyres. The device includes four interchangeable spheres, one to represent uniaxial minerals and the others to represent biaxial minerals with optic angles of 30°, 60°, and 90°.

Construction of the isogyrometer is explained, and its uses and limitations are discussed.

One of the most mysterious phenomena to the student in optical mineralogy is the behavior of isogyres in interference figures. There are methods of demonstrating isogyres on glass hemispheres (Hurlbut, 1955), and even on ping-pong balls (Bray and Staples, 1955), so that their behavior may be observed more clearly than it can be through the microscope. However, although these demonstrations are useful and impressive, they still do not reveal why the isogyres exist, or why they behave as they do.

Presented here is a rather simple but effective means of illustrating, by use of a mechanical device, the cause of isogyre behavior. With this device it is possible to trace the theoretical positions, and changes in positions, of the isogyres that a given mineral in a given orientation would yield on rotation of the microscope stage. The device is inexpensive and relatively easy to construct. Although some slight inaccurracies are involved, they are insignificant compared to the benefit derived by the student. Because the device is used to outline isogyres, it may aptly be called an isogyrometer.

CONSTRUCTION AND MATERIALS

Basically, the device consists of a box-frame supporting a rotatable sphere which can be viewed through a circular window representing the microscope field. The sphere is marked with lines representing the vibration directions of components traveling along radii of the sphere. The window is marked with lines simulating

* Present address: International Petroleum Company, Limited, Talara, Peru, S. A.

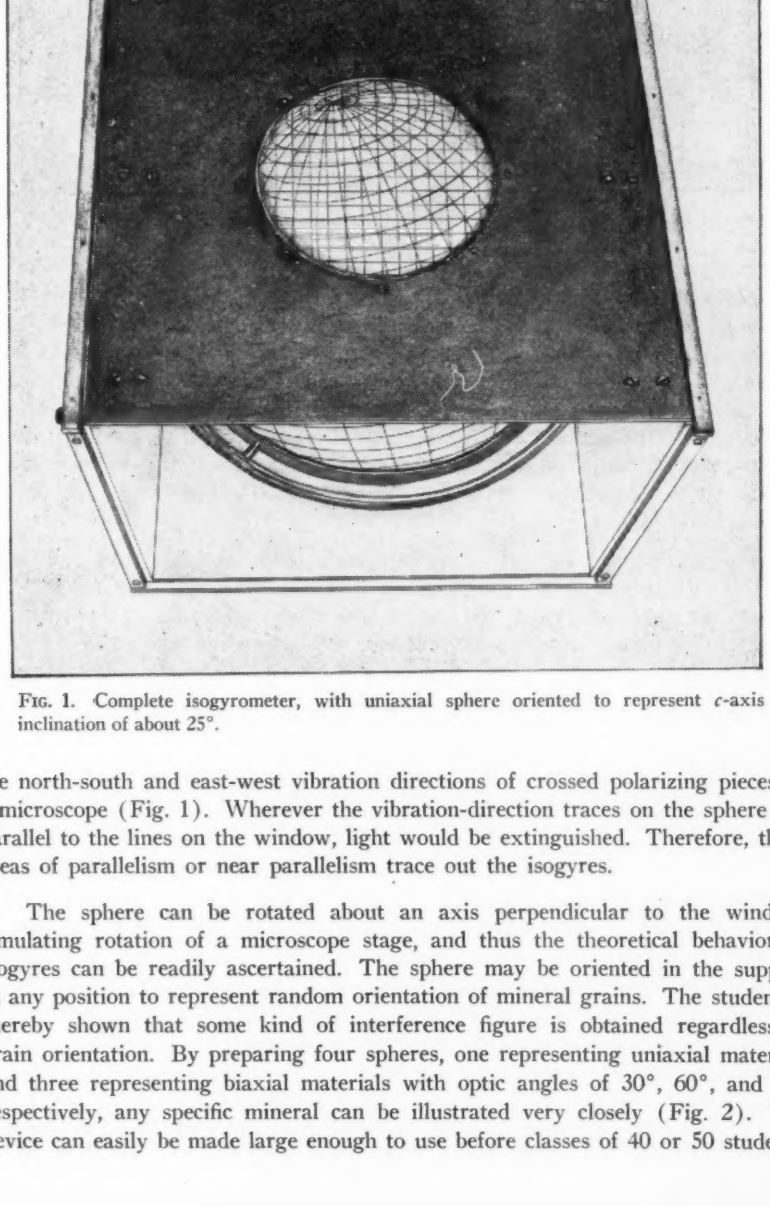

FIG. 1. Complete isogyrometer, with uniaxial sphere oriented to represent *c*-axis inclination of about 25°.

the north-south and east-west vibration directions of crossed polarizing pieces in a microscope (Fig. 1). Wherever the vibration-direction traces on the sphere are parallel to the lines on the window, light would be extinguished. Therefore, these areas of parallelism or near parallelism trace out the isogyres.

The sphere can be rotated about an axis perpendicular to the window, simulating rotation of a microscope stage, and thus the theoretical behavior of isogyres can be readily ascertained. The sphere may be oriented in the support in any position to represent random orientation of mineral grains. The student is thereby shown that some kind of interference figure is obtained regardless of grain orientation. By preparing four spheres, one representing uniaxial materials and three representing biaxial materials with optic angles of 30°, 60°, and 90° respectively, any specific mineral can be illustrated very closely (Fig. 2). The device can easily be made large enough to use before classes of 40 or 50 students.

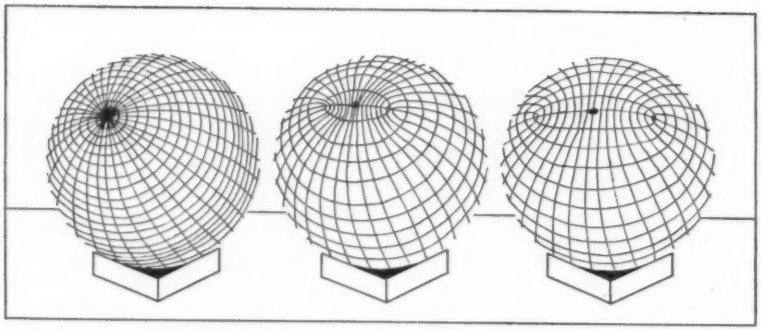

FIG. 2. Spheres lined to represent uniaxial materials and biaxial materials with 30° and 60° optic angles.

Although there are several way to construct a demonstrator of this kind, an outline of the method used by the author is presented here.[1] The frame consists of a wood bottom, two wood sides, and a masonite top which is removable to facilitate changing spheres. The top is held in place by means of small steel angles which slide into recesses in the wood sides. The window in the top is made of one-fourth-inch plastic and is supported by a brass ring. The diameter of the opening, that is, the inside diameter of the brass ring, is half the diameter of the spheres. It therefore represents a field diameter of 60°. For details and dimensions, see Fig. 3.

The rotating-ring support, or outer ring, is made as follows: A steel band $\frac{1}{16}$ x $\frac{3}{4}$ inch is formed into a circle about 16 inches in outside diameter. On the inside of the ring, at the upper and lower edges, copper tubing 0.2 inch in diameter is welded. However, because steel pins need to slide on the tubing, as explained below, steel tubing would probably be more satisfactory. The outer ring is fastened to the wood sides with screws. The rotating ring, or inner ring, which holds the spheres, is also made from steel band $\frac{1}{16}$ x $\frac{3}{4}$ inch. To facilitate reorienting or changing the spheres, the circumference of the ring may be expanded or contracted by means of a cam screw. (The cam-screw arrangement has not been altogether satisfactory; probably a spring mechanism on the inner ring to hold the sphere would be better.) The inner ring is supported in the outer ring by means of three steel pins which project from the inner ring and extend between the tubing almost to the outer ring (Fig. 3). The inner ring is easily removed, when not holding a sphere, by slight deformation. The frame is equipped with rubber feet on the bottom and on one side.

The spheres are 14-inch painted balls designed for world globes. They were purchased from Weber Costello Company, Chicago Heights, Illinois. They are very nearly true spheres and have small holes representing the poles and a narrow band representing the equator. Drawing lines to represent accurately the vibration

[1] The author is very grateful to Mr. S. Earl Dickens, instrument maker at Colorado School of Mines, for many valuable suggestions, and for supervising construction of the device.

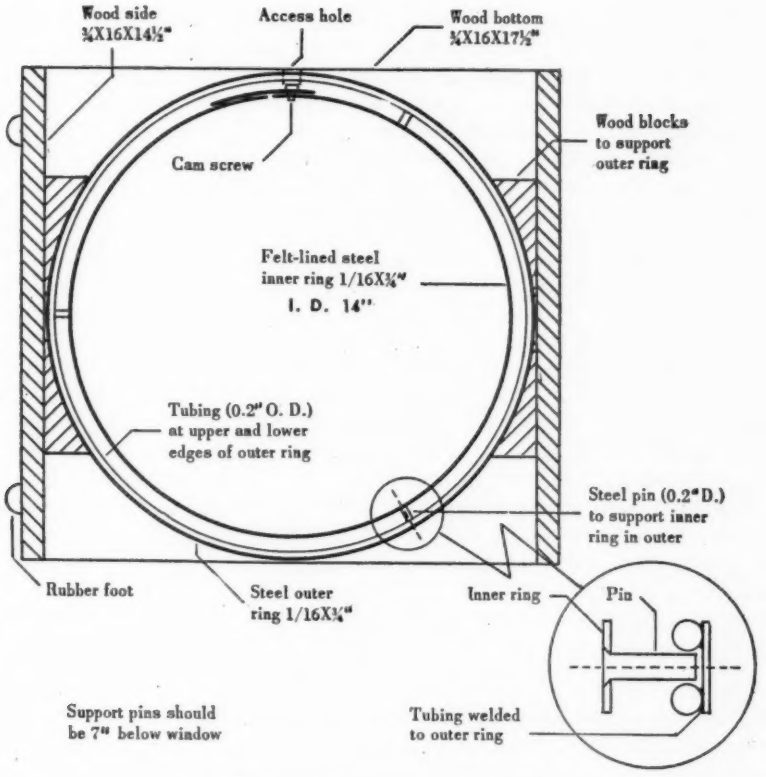

FIG. 3. Plan view of isogyrometer with top removed.

directions, or lines of equal velocity (isotaques), is not easily accomplished. The most satisfactory method employed for the "uniaxial" sphere involves use of a drawing compass. With suitable extensions on the compass, and choosing the holes in the sphere as the points of emergence of the *c* axis, the equator is located by trial and error — that is, as being the line equidistant from the center of the two holes.

The distance on the sphere between the equator and each hole is divided into 18 equal parts, each part representing 5°. With the compass a small circle is drawn through each division point, using the centers of the taped-over holes as origins. These small circles are equivalent to parallels of latitude on the earth, and represent vibration directions of the ordinary component. It was found that India ink would not go on the untreated paint smoothly; the surface may be roughened with a fine abrasive paper. Some practice and much care are necessary to draw satisfactory circles of large radii. Nevertheless, by this method it is even possible to draw a reasonably smooth and accurate equator.

The vibration direction of the extraordinary component is represented by lines equivalent to meridians of longitude on the earth. All these lines are great circles intersecting at the poles, i.e. the points of emergence of the *c* axis. These circles are more difficult to draw than the small circles. The equator is divided into 36 equal parts, so that each part represents 10°.[2] Using the division marks on the equator as origins, great circles are drawn with the compass just as the equator was. After all the "parallels" and "meridians" have been drawn, the sphere is given a heavy coat of plastic spray to prevent smudging of the lines.

The spheres for biaxial materials are considerably more difficult to line, because the curves representing vibration directions are spherical ellipses. The method used, more or less successfully, is as follows. Using the compass as described above, three mutually perpendicular great circles are drawn to represent the principal planes of a biaxial mineral. The structural equator of the sphere is chosen for one of these. The other two great circles pass through the two holes in the sphere. One of these passing through the holes is chosen to be the optic plane. Considering the holes to be the ends of the acute bisectrix, four holes about one-eighth inch in diameter are drilled through the skin of the sphere on the optic-plane trace to represent the ends of the optic axes. Of course, any optic angle may be chosen, but angles of 30°, 60°, and 90°, for three spheres repectively, give a good coverage of biaxial materials. Steel rods about one-eighth inch in diameter are inserted in the optic-axis holes (Fig. 4). The rods do not need to extend completely through the sphere, because inside the sphere at the equator is a plate with a fairly small hole at the center. The rods, being passed through the surface holes and the center-plate hole, are held in position satisfactorily.

The rods, projecting somewhat above the surface of the sphere, are used as foci for drawing the ellipses as shown in Figure 4. A piece of strong non-stretching cord, equal in length to the distance between the rods, is tied between two lengths of chain. The links of the chain should be small, one-eighth inch or less, but large enough to pass small wire. Hooks of small wire are fashioned on the rods so that any link of the chain can be attached closely to the rods. By hooking the chains to the rods in this manner, a pen or pencil held with adequate tension against the cord and moved along the sphere describes a spherical ellipse. Ellipses can be drawn through any point on the sphere by adjusting the length of chain between cord and rod by means of hooking into different links.

The distance between each bisectrix and the Y axis, along a great circle, is divided into nine equal parts, each representing 10°. Ellipses are then drawn through each division mark. One set of ellipses is drawn about the acute bisectrix and another set about the obtuse bisectrix. The vibration direction of one component at any point along a curve is the direction of the tangent at that point. The vibration direction of the other component is perpendicular to the tangent. At points where the curves intersect, tangents to the two curves represent vibration directions of the two components. Therefore, the curves must always intersect

[2] Spacing the "parallels" 5° apart and the "meridians" 10° apart gives a better density than having all the lines either 5° or 10° apart.

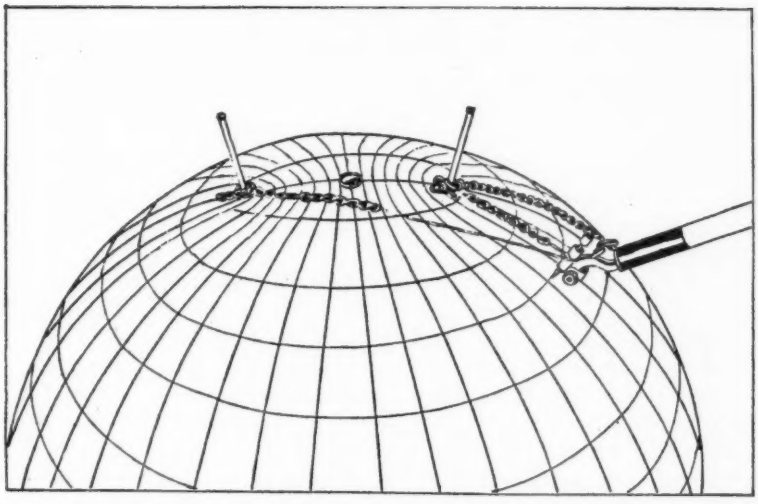

FIG 4. Method for drawing spherical ellipses with lettering-set pen.

at right angles. This condition serves as somewhat of a check on the accuracy of the curves.

One difficulty encountered in this procedure is that, with the larger ellipses, friction between the chains and the sphere produces sufficient drag to deform the curve. Most of this difficulty can be overcome by reducing tension on the chains and cord and by tilting the sphere so that the weight component of the chain acts tangent to the sphere's surface rather than toward its center. Even so, considerable care is necessary to minimize inaccuracy of the ellipses.

Two methods of drawing the ellipses can be used. The curves can be drawn first in pencil and then carefully inked. The advantage of this method is that errors made in pencil are easily corrected. In the other method, the curves are drawn directly in ink using a lettering-set pen and holder. The holder for the nib affords a means of connection to the cord, as shown in Figure 4. The advantage of this method is that free-hand inking is unnecessary.

SPECIAL USES

This device has been of considerable help to many mystified students. They can set up a given mineral in any orientation, and check the theoretical behavior of the isogyres. With proper lighting and paper, the isogyres can be traced for each 5° or 10° of rotation of the stage to record the behavior. Some of the more subtle features of interference figures become readily apparent. For example, in biaxial and uniaxial flash figures, the isogyres leave the field by the quadrants being entered by the acute bisectrix and *c* axis respectively; the optic-plane isogyre is narrower than that normal to it; rotation of an isogyre on an optic axis is

opposite to the rotation of the stage; uniaxial flash figures, obtuse bisectrix figures, and biaxial flash figures may be indistinguishable; and, most important, the positions of the optic elements can be readily determined from interference figures.

LIMITATIONS

Some inaccuracies are inherent in the device. For example, the field diameter is fixed at 60°, whereas the apparent field diameter of a microscope depends on, among other things, refractive index of the mineral. The amount of rotation necessary for the isogyres of a centered figure to leave the field of the isogyrometer is the same for minerals having the same optic angle. Actually, of course, this is true only if the indices are the same. Also, observing lines near the edge of the field with the line of sight normal to the window introduces some error. The observation should be made with the line of sight directed toward the center of the sphere. To minimize this effect, the sphere should be kept as close as possible to the window. Also, for best performance, the inner ring should support the sphere along a great circle. Both these conditions can be met only if the distance from the window to the center of the inner ring is exactly half the sphere diameter. Resting the sphere on a small block of proper thickness when loading will place it properly in the inner ring. As soon as the inner ring is contracted to hold the sphere, the block may be removed.

There is no doubt that many improvements can be made on the method outlined. Suggestions for improvements, or descriptions of similar devices, will be welcome. In any event, even in its primitive form the isogyrometer it has been very useful, and it is hoped others may find it so also.

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DISCUSSION OF THE IMPENDING SHORTAGE OF TEACHERS

As reported in the Fall 1958 issue of the *Journal* (page 36), the 1958 meeting of the East-Central Section featured a panel discussion on "Solutions to the Pending Teacher Squeeze." Panelists were J. R. Coash, Bowing Green State University; R. H. Mahard, Denison University; V. E. Nelson, University of Kentucky; and D. M. Scotford, Miami University. A well-edited transcript of the discussion, by the panelists and members of the audience, has been prepared by the symposium moderator, Dr. H. G. Multer. A limited number of copies of the transcript are available, on a basis of one per customer, first come first served. Requests should go to Dr. Multer, Department of Geology and Geography, The College of Wooster, Wooster, Ohio.

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TRAINING NEW ZEALAND'S GEOLOGISTS

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ABSTRACT. Although Federal surveys and provincial reports were published in New Zealand even earlier than in the United States, and the geological profession has long been established, there are only about 150 geologists in the country. Public interest in geology is strong, because volcanoes, earthquakes, and glaciers are in everyone's experience. Yet only about 20 Bachelor's degrees in geology are awarded each year by the four universities. The curriculum concentrates on science, with little attention paid to the humanities or arts. Only about half those who start to major at "Stage I" finish with a degree in geology. About seven of these go on to take advanced degrees. This supply more than satisfies New Zealand's need for new geologists.

DEMAND FOR GEOLOGY

For a small country consisting of two principal islands only as big as Ohio and Kentucky, and settled over a century and a half later than America, New Zealand is surprisingly progressive in geology. This stems first from the fact that settlement was by European intelligentsia seeking virgin fields. First-rate geologists like Julius von Haast published extensive and monumental surveys as early as 1861. There were provincial surveys between 1861 and 1879, and the New Zealand Geological Survey was established in 1865, at least seven years before the U. S. Geological Survey! A second reason for development of geological studies is that New Zealand's growth has been linked with exploration for gold (1860 to 1900), and then for coal (1880 on). Public interest is now directed toward uranium and hydro-electric developments; to date these problems have been handled by engineers, but all signs point to increasing use of engineering geologists. Meanwhile, exploration for mineral wealth in virgin territory (Southwestland, Ross Dependency) goes on apace. It is natural that earlier work should have been predominantly economic, but today there is much interest in a number of other fields of geology.

As of 1958 there were not over 150 geologists employed in New Zealand. (There are 197 members of the Geological Society of New Zealand, of whom some are retired and many are in foreign lands). Of the 150, about 20 (13%) are teachers, and about 50 (33%) are with the Geological Survey. The limited and so far most unrewarding activities of oil companies use less than 25 geologists, as compared to 14,000 in our AAPG! No wonder that a relatively small number of geologists, trained at only four universities, satisfies New Zealand's present needs. The demand is for only about 10 new geologists a year.

SCHOOL INTEREST IN GEOLOGY

Little is done in the "primary" (elementary) schools to attract children to geology, yet almost everyone you meet, even in the "back country," knows what a geologist is. Bits of information on economic resources and their discovery are included when the child of 6 to 12 studies one country, then another, in daily geography class. Unfortunately, although teacher training involves a uniform 14 courses, very few teachers get any geology; it is not required, and extras are rarely possible. Some claim that the one required course in geography is short and ineffective in geology. But many teachers are *interested* in geology; living in an area of active volcanoes, frequent earthquakes, young mountains, and active glaciers, one can hardly escape an interest.

Geography is continued as a subject in high school, and fully 60% of the students take it. Geography is a favored alternate on "School Certificate"[1] and "University Entrance" examinations at the end of the 5th (Junior) and 6th (Senior) Forms. Unlike geography in the U.S., which is chiefly a social science, geography in New Zealand is largely physical, and the teacher in the larger high schools has had up to three years of geography as well as some geology. Thus, although two-thirds of all students drop school by the end of the 5th Form (no one *has* to go after age 15), all know a few rudiments of geology.

STANDARD UNIVERSITY TRAINING

Only about 3% of high school students (4.2% of the boys and 2.1% of the girls) continue in university studies in New Zealand (compared with 35% in the U.S.). None of the geography classes, and few radio programs or books, are calculated to attract students to the geological profession as such. Yet the entering university student must decide which subject he will "read" (major in) during his first year.

Geology is a major in the "Faculty" (college) of science, so it is rarely taken by students in arts. As an elementary course, "Stage I" draws only from other sciences and engineering. Every course is a full year long, and a B.Sc. is awarded for 8 such units. Thus you don't take many subjects. Geologists must have one or two full years of physics, chemistry, zoology or botany, and "pure maths," so their science background may be greater than ours. But there is little or no opportunity for work in liberal arts or the humanities.

The geology curriculum consists mainly of three year-long courses: Stages I, II, III. Stage I is a general physical-historical survey, suitable for majors in any science, and it may have 30 to 100 students at a time. Stages II and III give more advanced work in geomorphology, structual geology, petrology, paleontology, and New Zealand stratigraphy, to 5 to 15 majors. Each is somewhat more time-consuming and rigorous than any two-semester U.S. course. And who teaches it? It is swapped about from one "lecturer" to another as the subject matter dictates.

[1] School Certificate is a ticket to better jobs or slightly better pay throughout New Zealand.

Of course there is only one professor in each department, and he is synonymous with chairman.

The New Zealand undergraduate is more on his own than his U.S. cousin. Geology I meets four times a week and then there are 4 hours of supervised "practical work" (laboratory). There are regular conferences with the "tutor." There may be 2 or 3 tests during the year too, but most of the grade depends upon the final. This is an ordeal of two 3-hour "papers" in October. At the end of 3 or 4 years, the student sits for "finals" and gets a B.Sc. if successful. If he does very well, he may elect to stay 2 more years and "read for honours."

The four New Zealand universities together have about 80 to 100 geology majors. Half of those who intend to major at Stage I actually finish; standards are high. There may be about 20 successful new geologist graduates in all New Zealand each year.

ADVANCED DEGREES

Emphasis has always been on practical field training. As in Canada, most young geologists gain experience by assisting on summer field parties. This work may begin after Stage II or Stage III, but invariably precedes serious graduate study. No regular summer field stations or schools are necessary. The trials of rain, sand flies, and long traverses without roads, test the serious intent of the man!

The Master's degree means 2 more years of seminars, independent study, papers, and a thesis. The Ph. D. is based upon 4 years of supervised research while teaching on the junior staff. And then there is a Doctor of Science degree, awarded on published work on research at any time; this is the senior degree and is not supervised, nor is residence at the university essential. There may be 7 of these advanced degrees awarded in any year, but rarely more than one of each kind of advanced degree at each university.

Until 1957 all four universities in New Zealand (Aukland, Victoria, Canterbury, Otago) were colleges under one University, and all advanced degrees were awarded by one examining committee of *the* University of New Zealand. Now each university is autonomous, and degrees may vary more. English geologists with advanced degrees emigrated to New Zealand in large numbers in the last few decades and took perhaps 20% of the jobs offered, and it was fashionable for New Zealand-trained undergraduates to go "home" (Oxford or Cambridge), or to America, to take an advanced degree. It follows that a number of geologists trained in New Zealand end up working in other countries, particularly Australia, Canada, or the U.S.

There are about 335,000 high-school pupils in New Zealand today (out of a population of 2,200,000). Of these, only 10,000 will go to a university, and less than 100 will major in geology. At least 50 will get the Bachelor's degree in geology, and 25 will eventually get a Master's degree or Ph.D. Thus New Zealand is, and will continue to be, a leader in geology, because its trainees and imported geologists are ample to meet the demand, they are well-trained field men, and the country is a small one.

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HISTORICAL GEOLOGY FOR THE GEOLOGY MAJOR*

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ABSTRACT. Historical geology has been modified to provide more adequate background for geology majors specializing in petroleum and geophysics. Ways are suggested of adding material in the fields of sedimentary tectonics, structural evolution of provinces, methods of dating, and usage of stratigraphic nomenclature.

At R. P. I. the freshman year is common for all students and does not include any geology. This common year permits some of the required courses in mathematics, physics, and chemistry to be completed. All geology courses are taught entirely to majors, and only occasionally does a non-major take one as a technical elective. The sophomore year begins with a 5-credit course in physical. (This course is also given to students in other departments, but on a less concentrated basis.) The second term includes mineralogy, geomorphology, and historical. In the fall of his junior year the student takes petrology, paleontology, and a field course. This is followed in the spring by structural, stratigraphy, and subsurface methods, and these by the summer field camp. Senior courses include petroleum geology (two semesters), reservoir geology, optical mineralogy, geophysics, ground water, and economic. Nearly all of our graduates are employed directly in the petroleum industry, or enter graduate school.

To provide the background for paleontology, stratigraphy, structural, and petroleum, and to permit these courses to move at the required pace, we have found that historical can no longer be taught on the level of the simple survey course. Before discussing the changes in emphasis which have been made, it should be pointed out that the success of the historical syllabus is directly related to the fact that this course follows an unusually comprehensive and expanded 5-credit course in physical, and is offered concurrently with a 7-contact-hour course in geomorphology, in which the physiographic survey of the United States is treated to a greater extent than is possible in historical. This order of presentation has provided space in the historical syllabus for the things which need to be included. In adition, historical is taught to sophomores, who, by this time, have survived the rigors of the freshman year and are prepared to begin concentrated work in their professional field.

In deciding on the direction in which modification of the course should take place, it was first necessary to decide what the course should accomplish. Should it survey briefly all the geologic events which have taken place, in their proper order, or select a few events and show the methods used in evaluating earth history,

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or both? In physical, the student was led through the processes which contribute to the construction and alteration of the earth's crust, the meaning of land forms, and so on. The next course, in historical, might naturally project this understanding to such questions as "How do we know when events occurred?" and "What lines of evidence are useful in determining when?" It seemes far more logical to help the student find ways of answering these questions than to acquaint him with all the diverse and frequently unrelated events which have taken place in the geologic past. It is necessary, however, to maintain a balance between "chronology for chronology's sake" and over-specialization in analyzing "the tools of the trade". With this in mind, the following subjects, normally offered later in the curriculum, have been introduced into historical geology. The chronological framework is used, but is modified as opportunities to use these subjects occur.

1. *Sedimentary tectonics.* In physical, the student has been shown the differences among such rocks as quartzite, arkose, and graywacke. But, even if he has not been shown, he can still be impressed with the idea that some sediments are thin and clean and others are thick and dirty. Historical seems to be the perfect place to initiate the study of why sedimentary rocks have different lithologies and thicknesses from place to place, and how the tectonic framework of the area of erosion and deposition contributes to these variations. It is much easier to start the student thinking in terms of isopachs, types of basins, and provenance of sediments, than to wait until stratigraphy to correct the many misconceptions which he will accumulate otherwise. How many times have we been asked, "You mean that limestone isn't deposited farthest from shore, next to the shale?"

Eardley, in his *Structural Geology of North America,* has compiled invaluable information on structural and sedimentary evolution, which is just as important in historical geology as the parade of life through the geologic past. His tectonic maps of the systems through the Cretaceous, and the résumés which accompany them, have been very useful in helping the student understand and visualize the relationships among orogeny, uplift and erosion, and sedimentation. In addition, we have expanded the maps and résumés to include three maps of Tertiary tectonics and one of the Pleistocene.

2. *The development of structural provinces.* Many illustrations can be cited as their turn comes in the normal chronological treatment of the course which will give the student a good comprehension of the complexity in time and space of some structural elements, and the simplicity of others. Consider, for example, Eardley's chapters on "Eastern Triassic Basins", "Mesozoic Systems along the Pacific", "Ouachita-Wichita System", and "Wyoming Rockies". What splendid illustrations of tectonics these are. Also, it does not seem inappropriate to acquaint the student with the differences between the Michigan Basin, the Ouachita Geosyncline, and the California Trough, for example, in order to demonstrate the variations in geosynclinal architecture and sedimentation.

We require the student to read portions of Eardley pertaining to the systems under study. This method accomplishes two important functions. First, it induces the student to think in terms of structural and sedimentary evolution of a province

over the span of more than one period. In this way it is much easier to relate evidence to event than it would be to tour the rest of the country on a survey and later come back to the same province after the scent has grown cold. Secondly, the student is introduced to some excellent technical writing, and this can't come too soon or too often. If he sees arkose and granodiorite in print occasionally he may be more receptive to this kind of word later on.

3. *Methods of dating.* Numerous laboratory problems normally saved for structural can be used in part in historical. Evaluation of hiatus, unconformities, restoration of complex cross sections to their original form, intrusive cross-cutting, contact and progressive metamorphism, and contemporaneous sedimentation over active faults or arches are but a few of the problems which relate just as well to principles of historical geology as to structural or petrology.

4. *Stratigraphic nomenclature.* The texts in historical geology seem to do an adequate job of preparation for paleontology. Stratigraphy is another matter. Perhaps the understanding of formations, zones, and facies could be aided if we had better illustrations showing actual field relationships, and fewer charts of names. The stratigraphic problems of the Gulf Coast and the Mid-Continent offer good sources of demonstration material. When studying the Permian we have found that the summary of the *Permian Reef Complex* by Newell and others provides good background material, not only on the Texas Permian but on facies and the changes in stratigraphic nomenclature involved with them. Again, the student reads from a source outside his textbook, and the lecture provides continuity and illustrations.

Finally, may I offer the following suggestions which have proved very useful in our course.

1. The student seems to mature more readily if the final portions of the course are designed to tax his imagination and ability more than the beginning portions. Even when historical is taught chronologically or by the survey method, it is not difficult to increase concept complexity in laboratory work in the Tertiary over that done on the early Paleozoic.

2. We should consider ways of modifying the strict chronological approach. Perhaps more principles could be taught if we worked provincially.

3. There is value in controversial subjects. The age of the Idaho batholith and the Glenarm series offer good examples. The student profits more from stimulation by two or more lines of conflicting evidence than he does when the solution is spelled out for him. It makes him feel intellectually competent to take a stand on an issue, and, even if he is wrong, he has had the invaluable practice of weighing evidence.

It is not easy to train a geologist in three years. But the job will be better done if we continue to evaluate our so-called elementary courses, which are really the most vital of all, to be sure that we are placing as much emphasis on principles as we are on details.

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ON TEACHING HISTORICAL GEOLOGY*

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ABSTRACT. Despite generally excellent conditions for teaching geology, we are confronted by several problems. One is that of a satisfactory textbook. A good text should include extensive treatment of paleontology and genetics, ecology, and correlation by fossils. It should also include sedimentary rocks and sedimentation, for that is where they belong—in historical geology. A second problem is that of laboratory; in this matter we are still experimenting. And our over-all, perennial problem is how to escape from an infinity of factual details.

WHAT WE WORK WITH

Each fall we greet a group of some 75 or 80 students in physical geology, most of them taking the course as their science requirement. Each June we say good-bye to 65 or 70 from historical geology; the mortality is not all of our making. Bryn Mawr students have had a comparatively good preparation at school and at home; they are very conscientious, and will actually *do* work that is assigned. We have all the equipment we need, within reason, and our staff is large enough to teach historical geology as it is often given: 3 hours of lecture and 4 hours of lab per week. We handle our courses entirely free from outside control. What more can we ask?

WHAT WE TRY TO DO

We give only one historical geology, and we make it serve for both the science requirement and for part of the first course for majors in geology. We think that these two objectives are compatible, and we would not want to give any other type of course. Whatever the requirements and formalities, I suppose that we also try to spread an awareness of the subject as widely as we can.

GENERAL IDEAS

As for what is usually called the "philosophy" of teaching the course—whether to follow the flow of Time, or to end up at Commencement well down in the Archean—the topic can be passed over quickly, for I do not have any ideas that seem worth imparting. I am, however, very much interested in the integrated course as outlined by Holmes (1956) in this Journal; if we can steel ourselves for the shock, perhaps we will try it some day.

In other numbers of the Journal, and elsewhere, articles advocate that historical geology be made to fit the students' needs; be widened to include more of other sciences; be lengthened or shortened; or be changed to have only field work,

* Presented at the annual meeting of the Eastern Section, N.A.G.T., at Princeton University, on April 20, 1957, as part of a symposium on the teaching of historical geology.

no indoor laboratory—or to have no laboratory at all. I am afraid that at Bryn Mawr we are rather reactionary. We *tell* the students what is good for them, make them work about as hard as we can without overworking ourselves, and we make the whole subject strongly competitive; they are told that quizzes and examinations are expressly designed to separate sheep from goats—if that is the proper expression for cultured young ladies. We are strongly against any type of general-education or survey course. We do not believe that a student can learn very much historical geology while trying to learn at the same time about ancient philosophers, conservation of natural resources, or how to adjust one's personality to Science.

My "general" ideas, then, are really specific. A few of them follow, and I am sure that most of them will be familiar.

PROBLEMS

If Holmes' integrated course were adopted, perhaps a number of the things listed below would no longer be pertinent, but to me they still are.

Subject matter and textbooks. The textbooks are inadequate—a euphemism if I ever heard one—and I find them boring beyond description. With such trenchant criticism, what suggestions have I to offer; why haven't I written a textbook? The answer is, of course, that I don't know what should go into it, but here are a few ideas.

The physical geology books—a different kettle of fish—are written on this principle: if anything is a process, or can be explained in mechanical terms, it belongs to them; all the other, inchoate, purely factual material belongs to historical geology. I will give just one outstanding example. The formation of sedimentary rocks, and the processes of sedimentation, are so integral and essential a part of historical geology—the very basis of it, of course—that to put them elsewhere reveals to me some strange weakness of the reason. Emmons *et al.* (1955) present 41 pages on sedimentation, and cover it very well. Dunbar (1949) devotes something less than 2 pages, and gives too much about the researches of that perhaps able, but somewhat out-of-date sedimentationist, Herodotus.

Some other things that must or should go in are, first of all, and comprising probably a quarter of the whole book, the following three subjects: modern work on genetics and on paleontology; and problems of correlation by fossils. The first two are usually omitted altogether, despite the fact that among significant advances in the field in the last five or ten years, these two subjects stand right near the top. The third is usually presented, in such attenuated form that anybody can understand it, but no one can profit by it. These subjects *must* be included, and must be treated well and fully; there is no other way to bring the origin and development of life to a focus, and to relate it to other parts of historical geology.

Second, much less essential, I admit, is a good, solid chapter or two on oil (I suppose we will have to call it "petroleum"). It should not be treated briefly, as just one more mineral resource, as in physical texts. And we can't afford to lose control of the most thoroughly studied branch of historical geology, just because there are some physical principles involved.

Just as important are the exclusions. The origin of the earth might just as will be left to the astronomers. A new theory every week is too much for the newspapers, let alone our textbooks. And for me, we might omit the long treatment of the Precambrian; the phenomena are the same in principle, only more obscure, and harder to unravel. And as for that pitiful little chapter, usually an appendix, which might be entitled: "How to Know All Animals and Plants By Just Looking at These Few Pictures"—!

Then, what would a good book be like? First of all, it has to have a lot more material in it than the student can handle easily. Let's say that it must be a text that a geology major would be glad to keep, to re-read, and to use as a reference throughout his geologic career; the old Grabau *Stratigraphy* had something of what I am groping for. By analogy, Moore *et al.* (1952) and Shrock and Twenhofel (1953) are excellent books for elementary paleontology; those books are *challenging.*

If you are going to write a historical geology text, I ask that it be a sort of modified Krumbein and Sloss (1951), with some paleontology and evolution added, and with most of the lithofacies maps thrown away. You might write it this way: each chapter to be a problem, the Cambrian for basal or sheet sandstones, the Ordovician for "valley" limestones, the Silurian for salt, and so on. The problems and the principles would be the important thing, and it wouldn't make the slightest difference if the student knew the names of only a few local formations. Surely, stick in a correlation table for the instructor, who can't remember things either. And if you are going to make a point of paleogeographic maps, would you *kindly* tell how they are made, and what they are intended to tell us?

For some years, I have not required any one textbook, but have named a number of equal (and doubtful) value. I make it clear that reading, along with the lectures, will be an essential part of the course; to help in selecting significant details from the welter of facts, I have given out mimeographed outlines. As an example, the one of the Silurian consists of two pages; it describes briefly the rocks of the eastern Lower, Middle, and Upper Silurian, their distribution, the names of a few well-known formations, and a paragraph on salt deposition. This mimeographed material, I tell the students, is about what they ought to memorize; it is roughly the amount of factual material that they should have available without too much mind-wracking.

But please be reassured: I never (or *almost* never) ask a "pure" memory question, such as "Describe the Silurian of North America". I can't bring myself to do it, in the first place, and I would surely die of boredom reading the answers. But more important, a question of this sort would have no value in differentiating good students from bad—they would all get 95 or 100. A question I liked at one time was, "What are the chances of finding oil on the moon?". Some mild complaints, after the quiz, that they knew nothing about the geology of the moon were, as diplomats say, rejected. To these students, and to all others, I try to stress the notion that it is more valuable to learn to use the brain, in whatever situation, than to know facts of geologic history.

Laboratory. I have had my main say, but if I left out the problem of laboratory in historical geology, someone would surely bring it up. First, we use no manual; we prepare all material ourselves. In the physical geology semester we cover only two things: rocks and minerals, and topographic maps, each about half the time. In the second semester, we used to do fossils for about half the course, and then a number of other things, including geologic maps, structure sections, and a stratigraphic problem involving columnar sections, correlations, and so on. We have changed, just this year, in several respects. We have about 2 hours per week on fossils, for six or seven weeks. For this part, I have been trying out keys for the phyla we study briefly; the students are required to identify and name specimens from the keys. So far, I do not know which is better, or worse: our older methods of looking at and drawing fossils, or the new one of looking at and trying to identify them. The other two lab hours involve maps and structure sections, and in the latter part of the semester we have taken to a quick survey of physiographic provinces and their geology; finally we do some detail on eastern Pennsylvania, particularly in preparation for the 3-day field trip, near the end of the course. This long field trip (we take two other, local ones) is the one thing we regard as an absolute must. I am sure that it does more to integrate the work of the whole year than anything else.

CONCLUSION

Finally, I am not against the learning of facts. You have to know that there was such a thing as the Paleozoic before you can do much talking about it (not true in some branches of learning). But facts must be subordinated to principles, and I have tried to point out a few ways in which this might be done. Of course, *everybody* is in favor of principles, as opposed to mere facts; even the authors of our textbooks say they are. Let's really make the facts incidental to the theories and principles, and let's give our students a bracing, challenging dose of the ideas behind the infinity of details!

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WHY TEACH HISTORICAL GEOLOGY?*

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ABSTRACT. The conventional survey of geologic history during the second semester of the elementary geology course at Lafayette College has failed to fulfill the desired functions of the course. This failure has led to progressive modification of the course plan. Of the various alternatives, the most effective appears to be a study of some of the basic problems of historical geology with reference to critical areas and sequences. This method has been applied to the laboratory portion of the course and is being developed further in the lectures.

For many years the elementary geology course at Lafayette College has consisted of a semester of physical geology followed by a semester of historical. We have, during most of this period, taught a conventional historical course — a period-by-period survey of earth history. Students in the elementary course at Lafayette include, in addition to prospective geologists, majors in the humanities, social sciences, and business administration, as well as in chemistry, civil engineering, and metallurgical engineering. This mixture of interests, motivations, and educational backgrounds is further complicated by restrictions of the engineering curricula, which permit engineering students to schedule only the first semester of geology. The elementary course at Lafayette must then meet the needs of a general education (in the arts curriculum), must satisfy the professional requirements of several different fields, and must have a terminal first semester.

Our experience with this complex microcosm has brought a good deal of dissatisfaction, even frustration. In particular we question the value of the conventional historical geology course. We estimate that at least eighty percent, perhaps more than ninety, of college and university geology departments offer a separate semester of historical geology following a semester of physical, and we suspect that the majority of these institutions teach a course of the earth-history survey type.

Examination of the popular historical textbooks substantiates this view, and also suggests a major weakness in the present system. These books are well-written, informative, and factual; perhaps too much so, for they can be used as the sole foundation for the course, in which case lectures are apt to become merely a supplement to the text. Under these circumstances the course may develop into the listing of a chronological sequence of events, with a great deal of rather dull repetition. Students may receive the impression that these events consist mainly of long periods of slow flooding of the continents, separated at regular intervals by much shorter times of disturbances, when life which previously had been

* Presented at the annual meeting of the Eastern Section, N.A.G.T., at Princeton University, on April 20, 1957, as part of a symposium on the teaching of historical geology.

prospering had a rather rough time of it. This life, further, might consist of long lists of fossil names, which, in addition to formation names and descriptions, are to be memorized but may be forgotten two weeks after the final examination.

Some teachers can, and do, with the aid of one of these texts, make historical geology a dynamic and inspiring subject, but even in certain of these cases about all that the non-major may be able to remember after graduation is that dinosaurs lived in the Mesozoic.

We now itemize the function which we believe the conventional elementary course should fulfill, with certain comments on our experience with historical geology.

(1) *Acquaint the student with the methods, results and philosophy of scientific inquiry.* Physical geology is superior to historical in this respect. To paraphrase Montgomery (1956) on the study of minerals, it is apparently true that in most historical courses there is too much to be memorized, with little need for the reasoning power of scientific inquiry.

(2) *Provide a cultural glimpse of the significance of earth sciences.* Historical geology gives some perspective on *Homo sapiens* in time, but the student tends to lose sight of this in the forest of dates and events.

(3) *Teach the embryonic geologist some of the fundamentals of his field.* The young geologist needs a background of historical geology, but very little of that given in elementary historical geology is retained. The details of geologic history are more easily taught to a geology major after he has a more thorough grounding in methods and principles. The majority of majors now in the Lafayette geology department feel that the physical geology course was the more valuable in preparing them for advanced courses.

(4) *Attract students into a geology major.* Many students find historical geology more interesting than physical, but most of these prefer it for cultural reasons. Few are interested in the scientific techniques behind the historical conclusions. In our experience, majors attracted primarily by historical geology lack interest or skill in advanced geology courses. Historical geology may thus present a misleading view of professional geology.

(5) *Give the student some conversational resources.* Historical geology is very successful in this area, especially if the student has a retentive memory, or confidence in his mis-recollections.

If the conventional historical geology course performs as badly as this, geology departments might be well advised to drop it entirely and concentrate on physical geology. This extreme has, however, certain obvious disadvantages. As an alternative, the elementary course might consist of a semester of physical geology followed by a semester in which the historical sequence is approached as a series of illustrations of the principles and methods learned in physical geology — with necessary additions on fossils and physical stratigraphy. This system clearly has

merit, and many "conventional" courses tend to evolve in this direction. There remains a good deal of repetition (not necessarily bad, but frequently dull) and the historical continuum is broken into a series of spasmodic episodes. The fossil record is still likely to be badly scratched in these jolts.

A second alternative would be a two-semester course, based on an extended treatment of physical geology, in which historical methods and data would be introduced as illustrations of physical principles. Again, this idea carries many attractive features, but the course would be difficult to organize and teach and would lose much of the historical perspective. Third, the entire course might be taught as historical (the method advocated by Holmes, 1956). In this concept the dangers to the scientific side are obvious, and the whole method of induction-deduction is likely to be obscured by the narrative. The concept seems impractical except for certain talented teachers.

Finally, we suggest a plan comprising a semester of physical geology and one of historical. The latter would consist of study of some of the basic problems in historical geology, with reference to particular geographic areas and historical sequences, in which the induction-deduction method and the principles and techniques are emphasized. The fundamentals of physical geology would, of necessity, be reviewed in a series of different frameworks. Paleontology would be introduced as one of the historical problems, and as a technique in correlation and in determination of ancient environments and geography. This approach may be the one most likely to attain the desired goals. We find that it is most applicable to laboratory work, although it is being increasingly used in lectures.

At Lafayette practically all of the laboratory work in historical geology consists of problems extending over several weeks. Some of the work is done in formal laboratory meetings, some in individual or group conferences, and some by outside reading and study. All problems are tied in with field trips and lectures. Each problem consists of three sections or phases: (1) An introductory phase, in which the student is introduced to the problem, the relevant portions of physical geology are reviewed, and new methods or concepts are brought out by exercise and discussion; (2) a problem phase, in which the student solves the assigned problem by means of maps, specimens, and field trips; and (3) a report phase, in which the student writes a paper stating his conclusions and how they relate to his observations.

This method eliminates the week-to-week terminal laboratory system which seems to be a fixture in a great many institutions.

One of the problems which we treat in this manner consists, for example, of the interpretation of the geologic history revealed in the rocks, structures, and landscape of the folded Appalachians of Pennsylvania. By studying rocks, fossils, maps, and selected publications, the student, in solving a single major problem, works with mineralogy, paleontology, and stratigraphy, and reviews a number of processes, including diastrophism and erosion — with some appreciation of the great length of time. Rather than memorize fossil names, he uses fossils in

interpreting environments of deposition. He employs physical geology to interpret geologic history — and it is not necessary to wait until the end of the semester to find out what happened in the Cenozoic. Geology means something to him whether or not he is going to major in it. He derives satisfaction from the revelation that his own reasoning power has carried him forward from one phase of the problem to the next. And the whole experience is stimulating to the instructor.

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BOOK REVIEWS

Basic Geology for Science and Engineering. Edward C. Dapples. 609 pp. John Wiley and Sons, Inc., New York, 1959. $9.50.

Professor Dapples' book is a treatment of the subject of physical geology which is written for students with a technical background. (It is not a book in engineering geology, as the title may seem to imply at first glance). Because he has written for the technically inclined, Dapples is able to give many basic concepts in geology a fuller and more logical treatment than is found in most elementary texts. Dapples uses a maximum number of graphs, and attempts to quantify data whereever information is available and suitable. Description of geologic field relationships is minimal, and is sacrificed (wisely, I think) for a deeper treatment of principles.

Dapples relates geologic phenomena and geologic terms to those in border sciences and in engineering. In so doing he partially counters the problem that a man may have an excellent background in geologic principles and yet have only slight real knowledge of the economic justification for its existence. Yet perhaps Dapples could have gone further in this direction. He discusses clay mineralogy in some detail without mentioning thixotropic effects and their engineering implications; he discusses sedimentation without saying anything about turbidity currents and their scientific and practical importance; he discusses the disintegration of rock by the expansion of ice without note of the breakup of highways because of this process operating on rock aggregate. Yet such things could be considered minor, for a book must certainly have some arbitrary limitations of subject matter.

Most of the book is devoted to subjects of particular interest to the "soft rock" group of geologists. For example, Dapples' treatment of the sedimentation processes, including the work of wind and ice, is extensive, clear, and well organized.

However, the vast subject of metamorphism occupies only 25 pages of the 609, and seemingly was added as an afterthought. The section on igneous rocks is also quite short, and some petrologists might object to the classification of igneous rocks, which is simplified to the point of being potentially very misleading.

Generally, however, Dapples' book is a good, clearly written exposition of introductory physical geology which is most suitable for petroleum-geology majors and other technically oriented students. It would be quite difficult for the average "arts student".

JAMES R. DUNN
Rensselaer Polytechnic Institute

Angular Relations of Lines and Planes. Donald V. Higgs and George Tunell. v + 43 pp., 23 figs., 9 plates (transparent overlays). Wm. C. Brown Company, Dubuque, Iowa. $2.75.

This book is designed to acquaint students of geology with those principles of *stereographic projection* and *spherical trigonometry*

which are useful in the determination of the angular relations of lines and planes.

Part I is concerned with graphical solutions of geological problems by means of the stereographic net. The section begins with a brief description of the stereographic net and some of its properties. The manipulation of the net then is explained, using seven illustrative problems. Each problem is stated first in its general form (for example, problem 3 involves the detemination of true dip from apparent dips in two different vertical sections), and then a specific geological example is given. Transparent overlays are provided for all the problems.

Part II deals with numerical solutions by means of spherical trigonometry. Equations for the solution of right spherical and oblique spherical trianges are derived, and a useful theorem on polar triangles is proved. Applications of these methods are illustrated using three geological problems.

Part I is reinforced by a short appendix containing additional background material relevant to this usage of stereographic projection. A brief bibliography also is included.

This book does not provide the teacher of geology with a packaged laboratory or field course. As indicated by the title, the book is concerned only with the angular relations of lines and planes with applications to geologic problems. There are no practice exercises to spare the teacher or student the bother of using his own imagination as to how the methods discussed might be further applied.

This book does provide the teachers of geology with a text which for the first time incorporates under one cover solid explanation of the methods of both stereographic projection and spherical trigonometry. The work is well-organized, clear, and precise. The transparent overlays furnished for each of the problems involving stereographic projection add greatly to the effectiveness of the explanations.

J. DONALD RYAN
Lehigh University

Vector Space and its Application in Crystal-Structure Investigation. M. J. Buerger. 347 pp. John Wiley & Sons, Inc., New York, 1959. $12.00.

This volume is a worthy companion to the author's *X-Ray Crystallography* of 1942. *Vector Space,* containing the same excellent combination of text and diagrams that can be found in the earlier work, provides the crystallographer with a systematic, comprehensive, and at times elegant, summation of the techniques for the determinations of crystal structures.

As Dr. Buerger notes in the preface, "the gathering of data for crystal-structure analysis is not discussed, and it is assumed . . . the reader . . . has an elementary understanding of Fourier synthesis as used in crystal-structure analysis." While *Vector Space* will therefore be of little use to the average geologist, it will prove an invaluable ally to those more advanced mineralogical students who are concerned with the exact configurations of the constituents of crystalline structures.

The contents of the book are systematically arranged in the order of historical development—from techniques permitting the analysis of simpler structures to those in which more complex situations become amenable to solution. Each section and its predecessors provide a firm foundation on which later sections are built. An exhaustive treatment of the Patterson function, Patterson projections, and electron density projections is followed by consideration of Harker sections, implication theory, the relations between fundamental sets and vector sets, and the theory and uses of image-seeking functions.

Each chapter is accompanied by a comprehensive annotated bibliography. Numerous specific examples are used to illustrate various techniques and possible situations. Author and publisher are to be complimented on the many excellent diagrams that accompany the text, which aid considerably in the clarification of its more involved aspects.

LESLIE C. COLEMAN
Department of Mineralogy
Ohio State University

Time, Life and Man. R. A. Stirton. xi and 558 pp., 291 line-cuts. John Wiley and Sons, Inc., New York, 1959. $9.00.

"This book is designed as a text for a course in introductory paleontology," according to the preface, where we also learn that the material has been presented by the author in such a course at the University of California for a number of years.

Plants and animals, vertebrates and invertebrates are treated, as well as a diversity of subjects commonly found in textbooks of historical and physical geology. These geological inclusions are understandable when it is realized that the text is written for a freshman course having no natural-science prerequisite, and is apparently designed to serve the general college student in fulfilling his natural-science requirement. As such, it is not an introductory paleontology text as the subject is usually conceived and taught. Hence for most colleges and universities this interesting and well-written book will best serve as a supplementary source for students in historical geology or evolution.

Most current books in the field are better illustrated. The minimal treatment of this book in this respect cannot but handicap the elementary student. The materials of paleontology, especially with respect to the invertebrates, are so unfamiliar that adequate pictures are required to supplement even the best of texts. The vertebrates fare better than the invertebrates and plants in this respect, no doubt reflecting the main interests of the author.

First editions commonly require correction. Among the items of this nature noted in the present book is the inaccurate (or certainly unclear) definition of fossils (p. 12), the repeatedly incorrect placing of the diacritical mark in Crô Magnon (pp. 519-520) and the statement, of special interest to the reviewer, that Big Bone Lick is a "marsh just above the site of the Louisville Falls". The drawing of an ammonite (fig. 204) represents the living chamber as something other than the last camera of the shell. It seems unfortunate that the problematicum *Thinopus* (p. 206) has been resuscitated as a potential Devonian amphibian, when best information, extant long since, indicates that it is not only inorganic, but from marine Mississippian strata; there are no continental pre-Pennsylvanian strata in the area from which it came. Finally, there is no merit in the failure of the editors to differentiate scientific names by the customary italics in the figure legends.

KENNETH E. CASTER
University of Cincinnati

1959 ANNUAL MEETING

The 1959 Annual Meeting of the National Association of Geology Teachers will be held at Ohio State University, Columbus, on December 4-5. Meetings of the officers and various committees will take place in the evening of Friday, December 4th. The morning of Saturday, December 5th, will be devoted to the annual Business Meeting and miscellaneous papers. Two symposia will be held during the afternoon, the first devoted to "The Teaching of Introductory Geology" and the second to "Honors Programs and Undergraduate Research". Invited speakers will lead these symposia, with ample opportunity for discussion from the floor. The meeting will close Saturday evening with a banquet at which the Neil Miner Award will be presented and the retiring president will give his address.

ACKNOWLEDGMENT

At its 1958 meeting, the East-Central Section voted to turn over the sum of $75.00 from its treasury to the *Journal of Geological Education*. A check in that amount has been received and deposited with the national treasurer for the *Journal's* account. On behalf of the N.A.G.T. officers and membership, the editor acknowledges with thanks this generous gift.

TRANSACTIONS OF THE
NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

NEW ENGLAND SECTION

The annual meeting of the New England Section was held at the University of New Hampshire, Durham, on April 3 and 4, 1959. Thirty-four members were present. The banquet on Friday evening was followed by an address by President Alonzo Quinn.

Ten papers were presented during the main program on Saturday. J. A. MacFadyen reported on a system of seminars in the geology department at Williams College, which are designed to replace required theses for juniors and seniors. His experience indicates that the students are not ready for the true seminar approach, and his course has evolved into a lecture course with experimental laboratory. A recently instituted program in geology at the University of Rhode Island was described by J. S. Kahn. The first group of majors will be seniors in the fall of 1959. N. M. Sage, Jr., University of New Hampshire, reported on the substitution of experimental laboratory or field work for "senior papers," and on a weekly seminar that is now in its second year. He stated that these features helped indicate to the staff which students are best capable of graduate work, and helped the students appreciate the importance of work in allied fields of science. F. D. Eckelmann spoke on a program of undergraduate participation in faculty research at Brown University. About once every two years, a qualified student is awarded some $400 and is assigned to assist a faculty member on a research problem. R. M. Garrels, Harvard University, described the content and mechanics of a course in geology, one of eight science courses offered in the "General Education" program. The course strives to acquaint the student with the great age of the earth, and with evolution through time; and to enable him to interpret what he sees when traveling, and to erect a sequence of events from identification of rock types, fossils, cross sections, and maps. About 85 students take the course; there are three lecturers.

Louise Kingsley, Wellesley College, described a means of countering the ignorance of geography on the part of beginning students: a large-scale physiographic diagram of the United States, kept up to date throughout the year, on which are plotted classic areas, important formations, and so on. She also stated that the traditional physical-historical sequence has been abandoned at Wellesley, in favor of extending physical geology throughout the year, each process being traced back from the present into the past. Brewster Baldwin, Middlebury College, discussed the use of ground-water reports as outside reading in beginning geology courses. A small gadget to help students understand the significance of the International Date Line was described by its originator, C. E. Miller, University of Rhode Island. C. J. Schneer, of the University of New Hampshire, pointed out some of the basic similarities between mineralogy and physical metallurgy. R. R. Shrock, M. I. T., presented large-scale charts to show trends in graduate study and employment. He believes the need for additional geologists will not increase as fast as the population increases, and advocates stiffening course requirements, recruiting better students, and emphasizing adequate preparation in mathematics, physics, and chemistry.

At the business meeting, the slate of officers presented by the nominating committee was unanimously elected (see back cover).

DONALD H. CHAPMAN
Secretary Pro-Tem

EASTERN SECTION

On Saturday, December 6, 1958 twenty-one geologists from Bryn Mawr, C.C.N.Y., Dickinson, Franklin and Marshall, Johns Hopkins, Lehigh, Princeton, Rensselaer, and the Maryland Geological Survey met at The Johns Hopkins University at the fourth annual informal meeting of the Eastern Section, National Association of Geology Teachers.

The group was first taken to the departmental library with its 40,000 books and periodicals neatly arranged in new stacks. Also arranged and catalogued are 20,000 maps in map cabinets. The department is fortunate in not only having a regular librarian who keeps current a catalogue by author for most

periodicals but also in having a map librarian who is actually interested and knowledgeable in keeping up the map catalogue.

The department is resisting, so far successfully, the transfer of the departmental library to a central general library, pointing out that 90% of the use of the library is by the Geology Faculty and Geology students and only 10% by people from other departments, and that a departmental library is most convenient since some work can be done even when only a few minutes are available. Also students given keys can work at any time of day or night.

The department agreed that for engineers a central library is convenient. Some books on geophysics now go to the Physics Department. A difficulty that the Geology Department has is that there is room for new additions to the department library for only about 4 or 5 years.

The group was shown the igneous and sedimentary petrology laboratories which are used for both undergraduates and graduate students. The group was also conducted through the laboratories for the study of phase relations and mineral equilibria under high temperature and pressure, the x-ray diffractometer room, the paleontology laboratory, and several classrooms and lecture rooms.

After lunch we met in a faculty lounge for a general discussion. At the Homewood Campus of The Johns Hopkins University there are 2400 undergraduates students, and 7000 students taking evening courses. An average of 3 or 4 Ph.D. degrees in geology are given per year. About half the graduate students receive this degree. There are generally 20 graduate students, 6 to 8 being new each year, with most receiving financial help in the form of scholarships, fellowships and assistantships. There are eight on the staff of the Geology Department. The graduate curriculum at Johns Hopkins is controlled by the fact that the major interest is in training research people rather than purely professional geologists.

In the undergraduate curriculum the Geology Major must stress courses in biology, chemistry, physics, and calculus before graduation, with some advanced courses in these fields taken in graduate school. Ernst Cloos feels that it is more important that the undergraduate student gets all these background courses even though it means less geology. Let him get the geology in graduate school. In fact, students have been taken into the graduate school who have had only general geology. Jacob Freedman pointed out a difficulty here. He noted that we must give the students enough geology in the undergraduate curriculum to maintain their interest or we may lose them to some other science.

In the Johns Hopkins undergraduate curriculum, of the total courses for graduation, the geology required courses plus the prerequisites in other sciences and mathematics adds up to one-half the courses. The student can spend one-half his time completely outside of any science whatsoever. The total geology courses required of the undergraduate is one-quarter of his total hours.

The Geology Department feels that liberal education includes science and knowledge in some field to a considerable depth. A man has not had a liberal education and is not educated to think if he has only had a wide range of beginning courses.

There are generally about six undergraduate Geology Majors, and about 20 to 30 students taking general geology. Formerly there were up to 125 taking general geology when there was a science requirement. In addition the undergraduate major takes crystal optics and crystal morphology, minerals and rocks, structural geology, invertebrate paleontology or stratigraphy, and field geology at Camp Singewald or equivalent. No economic geology or geomorphology is at present taught by the Geology Department. Geomorphology is taught in the Geography Department.

The field work is considered of prime importance since the present tendency to emphasize the laboratory makes the field work more necessary than ever in order to relate theory to geological facts. The students normally take the six-week course at the end of the Junior year. Camp Singewald is on a ten-acre site 100 miles west of Baltimore near Hagerstown. Generally 5 to 20 students take the course. During the regular school year there is a field seminar every Saturday, weather permitting, with all majors and graduate students participating.

Since the department is somewhat cramped for space, attics are being converted into rooms. The Maryland Geological Survey has been housed in the Geology building for many years, with the ground-water branch becom-

ing more and more important. The geology library is being built up by periodicals received in exchange for publications of the Maryland Survey.

The annual spring meeting of the Eastern Section was held on March 27 and 28 at Bryn Mawr College, Bryn Mawr, Pennsylvania. On Friday morning the members attended the annual meeting of the Pennsylvania Academy of Sciences at Schwenksville, about 25 miles northwest of Bryn Mawr. A field trip to crystalline-rock areas was conducted in the afternoon. Dinner was at The Deanery on the Bryn Mawr campus. A business meeting followed, at which new officers were elected (see back cover). The group was then addressed by E. H. Watson, who spoke on "Geology of the Bryn Mawr Area."

On the morning of the 28th there was a symposium on "The Place of 'New Fields' in Our Geology Teaching." Speakers were J. R. Beerbower, on statistics and paleontology; H. H. Hess, on geophysics and oceanography; H. D. Holland, on age determinations; and J. S. Penny, on palynology. The meeting concluded with an afternoon inspection of the Geology Department at Bryn Mawr, and of the new and unique Vaux collection of minerals just given to the college.

MAURICE B. ROSALSKY
Secretary

EAST-CENTRAL SECTION

The East-Central Section held its annual meeting on April 10 and 11, at Denison University, Granville, Ohio. About 30 members were present. On Friday afternoon, Richard Mahard and Charles Graham of Denison led a field trip to Mississippian outcrops west of Granville.

President Raymond Gutschick presided at the business meeting on Friday evening. The secretary-treasurer's report was read and approved, and new officers were elected (see back cover). President Gutschick reported on the national meeting in St. Louis. Karl Limper reviewed the career of William H. Shideler, a great teacher and a recipient of the Neil Miner Award, who died on December 18, 1958. V. E. Nelson, of the University of Kentucky, invited the East-Central Section to meet next year at Lexington, in conjunction with the Southeastern Section of the G.S.A., and possibly with the Southeastern Section of the N.A.G.T. The invitation was accepted. Representatives of Bowling Green, Notre Dame, Ohio Wesleyan, and Prudue expressed hopes of acting as hosts for future meetings. Sidney White called the membership's attention to the next annual meeting of the N.A.G.T., to be held at Ohio State University, Columbus, on December 4 and 5, 1959.

After a discussion of possible symposium topics for next year's meeting, it was moved and passed that the topic be "Careers for Geologists, and Changes in the Curricula to Further the Needs of Students."

It was voted that the sum of $75.00 be turned over to the *Journal of Geological Education* from the Section's treasury. The secretary was instructed to write to Dr. M. F. Marple, retiring editor of the *Journal*, expressing the Section's gratitude for her excellent work. The business meeting adjourned with an expression of thanks to Drs. Mahard and Graham and their wives for their kindness and hospitality.

Features of the stratigraphy in the vincinity of Granville were studied on a field trip on Saturday.

C. L. BIEBER
Secretary

CENTRAL SECTION

The 19th annual meeting of the Central Section was held at the Nicollet Hotel, Minneapolis, on Sunday, April 12, 1959. The minutes of the previous meeting were approved as published in this *Journal*. President Grawe reported on his activities during the year. The reports of the treasurer and the budget committee were approved, and new officers were elected (see back cover).

The question was raised as to what can be done to make the Section meetings more useful and attended by a greater percentage of the membership. It was suggested that when meetings of large geological societies are held within our region, the Central Section could meet before or after the other society's meeting. In the absence of larger meetings, the Section could well afford to sponsor a separate meeting, with invited papers and a program to be announced ahead of time.

The year 1960 will bring the 20th annual meeting of this Section. The new Vice-President, who is in charge of the program, will appreciate an invitation from some institution

for a place to hold the meeting, and any suggestions of subjects to be discussed.

Dr. Chalmer Roy, chairman of the A.G.I.'s Education Committee, discussed the committee's program. Activities include (1) sponsorship of the Duluth Conference for Development of Teaching Resources in the Geological Sciences, which is designed to improve earth-science teaching at the pre-college level; (2) sponsorship of the Visiting Geoscientist program, through which some 47 geologists and geophyiscists will make about 70 visits to geology departments; (3) a planned program of film evaluation, with publication of an expanded, annotated list of movies; and (4) a contemplated study of geologic curricula and course content.

A brief discussion of job opportunities for geologists brought forth the suggestion that we have not fully explored some "secondary" fields. These include the National Park Service, soil conservation work, mineral policy planning for Government agencies, and administrative positions in such large organizations as the N.S.F., N.R.C., G.S.A., and others.

DOROTHY J. GORE
Secretary

SOUTHEASTERN SECTION

The annual meeting of the Southeastern Section was held on April 17, 1959, at the University of North Carolina, Chapel Hill. The meeting opened at 2:00 p.m. with Vice-President William R. Higgs presiding in the absence of President E. Willard Berry, who is on leave in Europe. The other officer present was Secretary-Treasurer Casper Rappenecker. A total of seventeen persons signed the roll, representing thirteen colleges and universities and one consultant, all within the Southeastern region, including North Carolina, Kentucky, and Louisiana. The meeting was informal throughout, with nearly everyone taking part. The discussion centered around what should constitute a strong undergraduate curriculum. It was agreed that there is need for a curriculum which would provide a good foundation for graduate work, and also give the baccalaureate graduate a strong competitive position for employment. Several persons thought that greater emphasis in the fundamental areas of mineralogy, structure, paleontology, and stratigraphy, and a decrease in the technological aspects was necessary. General agreement was found for the idea that the N.A.G.T. was the most logical organization for setting up standards for geological curricula and accreditation of departments of geology; and that the Association should move more rapidly in this direction than it had heretofore. In the realm of graduate studies there was time for consideration of only one item, which was: one language is a reasonable requirement for the M. S. degree.

Although the meeting was held at the same time as one of the sessions of the Southeastern Section of the G.S.A., it was considered successful. The meeting adjourned at 4:45 p.m.

WILLIAM R. HIGGS
Vice-President

PACIFIC NORTHWEST SECTION

The annual business meeting of the Pacific Northwest Section was held on December 30, 1958, at Oregon State College, Corvallis. President Norman Anderson called the meeting to order after an informal luncheon in the Memorial Union. It was voted to dispense with reading of the minutes, since they have been published. President Anderson reported that the nominating committee had notified him of the unanimous election of new officers by mail ballot (see back cover).

In accordance with suggestions made at the meeting of December 1957, the president announced that the first Section-sponsored workshop for informal discussion of teaching college geology, promoting lower-level earth-science courses, and exchanging laboratory materials, would be held at the College of Puget Sound, Tacoma, Washington on March 14, 1959. A round-robin letter, announcing trading stock of laboratory and demonstration materials, would shortly be sent to institutions whose departments of geology include N.A.G.T. members. The business meeting was then adjourned.

During the afternoon session of the Geology-Geography section, Joint Oregon Academy of Science — Northwest Scientific Association, four N.A.G.T. papers were presented. Appeals for membership during the day resulted in five endorsed candidates.

The next meeting will be held with the Northwest Scientific Association, in December 1959 at the Davenport Hotel, Spokane, Washington.

EDWARD P. THATCHER
Secretary

THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS was founded in the Middle West in May, 1938. In November, 1951, it was organized as a national association, under which there are at present seven organized regional sections: Central, East Central, Eastern, New England, Far Western, Southeastern, and Pacific Northwest. An annual meeting of the national association is normally held in the fall, and sectional meetings are held in the spring.

The purpose of the Association, as stated in its Constitution, is "to foster improvement in the teaching of the earth sciences at all levels of formal and informal instruction, to emphasize the cultural significance of the earth sciences, and to disseminate knowledge in this field to the general public."

Anyone concerned with geological education, formal or informal and at any age level, is invited to apply for membership. *Inquiries should be addressed to the national secretary,* FREEMAN FOOTE, Williams College, Williamstown, Massachusetts.

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